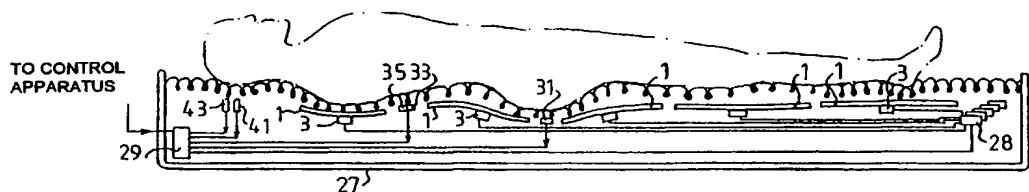


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**(54) Title:** METHOD AND APPARATUS FOR SUPERVISION OF HEALTH PARAMETERS**(57) Abstract**

A mattress comprises a number of sensors for registering body functions such as heart rate or respiration of a person lying on the mattress. The data is transmitted to a health care centre or the like, for monitoring the person's health parameters. Certain processing of the data may be performed locally in a computer, for example, to initiate alarms in different types of emergency situations. The mattress may also comprise vibrating elements for inducing calming vibrations and for preventing pressure sores.

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## Method and Apparatus for Supervision of Health Parameters

### Technical Field

The present invention relates to a supervision system for the automatic registration  
5 of data concerning people in need of care. A method for such supervision is also disclosed.

### Background

The increasing number of elderly people and the cutdown in public health care currently taking place in many countries will lead to an increasing number of people being taken care of in their homes. Also, with an increasing desire of health care more adapted to the individual, more people will want to be nursed at home rather than staying in hospitals or old people's homes. This will require improved techniques for communication and transmission of data regarding the state of the patient.  
10  
15

"Smart houses" are houses for people with special needs, for example elderly or disabled. In such houses, functions and services related to the diseases or handicaps from which the inhabitants suffer should be provided. Such functions may be, for  
20 example, if the person has a heart problem, monitoring the heart rhythm, or if the person falls out of bed.

A "bed guard" exists for use in so called smart houses. The "bed guard" is a small sheet, (100cm x 50cm with a thickness of 28mm) to be placed on top of the ordinary mattress. It comprises a pressure sensor registering if someone is lying on the bed. If the person leaves the bed for longer than a predetermined period of time, an alarm may be triggered, so that the person may be helped back to bed. This "bed guard" only registers presence, and transmits no other information than an alarm signal.  
25

Being a separate sheet, it is also easily moved or deformed, so that it does not function properly.

Patent Specifications US 5 515 865 and US 4 895 160 describe mattresses for the  
5 supervision of sudden infant death. The mattresses comprise pressure sensors for  
registering breathing and initiate an alarm if the breathing stops for a longer than a  
predetermined period of time. The system disclosed in US 5 515 865 also triggers  
actions to stimulate the infant if the breathing stops. The system disclosed in US 4  
895 160 also comprises other types of sensors, for example, for temperature and  
10 humidity in the room. The systems do not differentiate between different types of  
problems and no information other than an alarm is transmitted.

Biofeedback is a method of helping people control their stress levels, that is reducing  
the negative effects of stress in everyday life. The user is sitting or lying down  
15 while the reactions of the body, such as heart rate or breathing rate, are registered.  
the signals are amplified and displayed to the user, for example, on a screen or in  
the form of sound pulses. In this way, the user is informed about his own reactions  
and how they vary. Experiments have shown that it is possible in this way to control  
your physical stress reactions and relax better.

20

### **Summary of the Invention**

It is an object of the present invention to enable the automatic monitoring of one or  
more functions, such as heart rate and breathing, of a person lying on a bed.

25 It is still another object to facilitate the care and supervision of elderly, ill or disabled persons in their homes.

It is another object to provide a method and a system that will inform the appropriate persons when a person is in need of immediate care.

30

It is yet another object to enable the transmission of the registered data to a remote location such as a health care monitoring centre.

These objects are achieved according to the invention by a communications system  
5 for transmitting information about the state of a person, comprising a mattress comprising at least one type of sensor for registering at least one body function of a person lying on the mattress, and a communications module for transmitting data through a standard telecommunications interface.

10 According to a preferred embodiment, the communications module is adapted for wireless communication.

In a preferred embodiment, the communications system also comprises a signal processing means and means for converting the output signals from the sensors to  
15 input signals of the appropriate format for the processing means.

The mattress may comprise, for example, the following sensors

- pressure sensors in the hip region and/or chest region for registering presence and movements.

20 - acoustic sensors in the chest region for registering respiration and heart rate.

According to a preferred embodiment, the sensors are essentially the same type of acoustic pressure sensors, each transmitting a signal comprising a spectrum of frequencies. The processing means then preferably comprises functions for separating the signal frequency components.

25

A preferred embodiment of the mattress comprises air compartments surrounded by a flexible material, such as foam rubber.

30 The sensors may be located in the air compartments, each sensor being enclosed in an essentially hemispherical or hemicylindrical capsule. The walls of the capsule are

selected so that pressure changes from the desired direction are registered by the sensor whereas pressure changes in all other directions are attenuated by the capsule walls.

5 A method for using the apparatus is also disclosed in which the sensors register whether or not someone is present on the mattress. Other data is registered only when a person is found to be lying on the bed.

10 Data about a client's state may be transmitted, for example, to one or more of the following:

- family carers,
- responsible health care personnel,
- a specialist evaluating data over time,
- a service centre, from which health care personnel may be informed.

15 Data may be transmitted and/or stored for several different purposes:

- for the supervision of patients with certain problems such as heart arrhythmia or epilepsy, to assess the severity of the problems, development over time, etc.
- for calling health personnel or other help to a patient who needs care, for example who has fallen out of bed or needs immediate treatment,
- for updating the client's personal health record.

The invention offers the following advantages:

25 The possibility to send data directly related to the person's condition allows the receiver of the information to assess the nature and severity of the problems and to determine the type of assistance needed and the urgency.

The invention enables sick, elderly or disabled people to continue living in their homes even as their need of care increases.

30 The invention offers a system and a method that are adaptable to individual needs.

It enables the monitoring of data regarding patients without seeing a doctor more often than necessary.

5 It enables the automatic registration of several types of data, related to several types of problems, such as epileptic seizures, respiratory problems, heart trouble or physical disability.

There is no risk of the sensors or other components of the mattress being displaced, as they are an integral part of the mattress.

10

#### **Brief Description of the Drawings**

Figure 1 shows an embodiment of a mattress according to the invention seen from above.

15 Figure 2 shows an embodiment of a mattress according to the invention seen from the side.

Figure 3 shows the data processing units used in connection with the mattress according to an embodiment of the invention.

Figure 4 shows an embodiment of the data processing and communications system according to the invention.

20 Figure 5 shows, schematically, the data processing and communications system according to a second preferred embodiment of the invention.

Figure 6A shows a vibration element according to a preferred embodiment of the invention.

25 Figure 6B shows a cross section of a part of a vibration element according to a preferred embodiment of the invention.

#### **Detailed Description of Embodiments**

Figure 1 shows an embodiment of a mattress according to the invention seen from above. According to this embodiment, the mattress also comprises a number of vibration elements 1, each comprising a vibrating body 3 and a lattice 5 for distribut-

30

ing the vibrations to an area around the vibrating body 3. The mattress further comprises a number of sensors. It may also comprise one or more loudspeakers 11 for use in a biofeedback system.

5 A number of pressure sensors 13 located in the hip region of the mattress detect the pressure on the mattress, and thereby whether or not a person is lying on the bed. If the person leaves the bed for a period of time exceeding a threshold value, an alarm may be transmitted. The system is provided with software that registers, and adapts to, a pattern of behaviour for a certain person, so called habit cycle monitoring.

10 In the chest region, there are sensors 15 for registering heart activity, and sensors 17 for registering respiration. The sensors 15 for registering heart activity may be sensitive pressure or acoustic sensors registering sound or pressure or vibration sensors. The sensors 17 for registering respiration are preferably pressure or acoustic sensors or detectors.

15 There may be a second set of pressure sensors 19 arranged in the chest region of the mattress. This second set of pressure sensors 19 may be used together with the first set of pressure sensors 13 to register epileptic seizures, which are associated with characteristic movement patterns. The acoustic sensors may register other symptoms, such as coughing.

20 The sensors 13, 15, 17, 19 are preferably arranged in a mattress with air filled closed cavities, which will function as a resonance chamber, amplifying the sounds.

25 In the chest region there may also be a second set of pressure detectors.

The pressure sensors 13, 19 and the heart rate and respiration sensors 15, 17 may also be used to determine whether or not the person lying on the mattress is asleep, in which case he will move very little and the heart rate and the breathing will be slower. If the person wakes up at night, this will normally be detected by the system

as a period of tossing and turning. The vibration elements may start vibrating to induce sleep. The frequencies used should be adapted to the frequencies of the human brain in the state of relaxation and sleep, respectively. When a person lies down on the mattress, the relaxation may start with vibrations corresponding to the frequency 5 of the brain during sleep (0.5Hz-3Hz).

When a person lies down on the bed, calming pulsations may be initiated, which may have a frequency between 3Hz and 12Hz, corresponding to the frequency of the brain when a person is totally relaxed. This will cause the person to become 10 more relaxed. The frequency may then be reduced, step-wise if desired, to the frequency corresponding to sleep (0.5Hz - 3Hz). When the person has fallen asleep, the vibrations may stop. This is registered by one or more of the sensors 13, 15, 17, 19.

15 The pressure sensors 13, 19, the heart rate and respiration sensors 15, 17 may also be used together with a pair of loudspeakers and/or the vibration elements, in a bio-feedback system. The pressure sensors 13, 19 are then primarily used to register the presence of the person. Other sensors are only activated if someone is lying on the mattress.

20 In a preferred embodiment, the same set of sensors are used for registering presence, movements, heart rate and respiration. The sensors are then sensitive acoustic sensors, that register air pressure and changes in air pressure. Preferably, there is a group of four sensors on each side of the mattress in the chest region and one group 25 of sensors on each side of the mattress in the hip region. The signal registered by the sensors will then be a combination of a number of different signals with different frequencies. In the control device the different components are extracted using analysis methods known in the art.

According to a preferred embodiment, each of the acoustic sensors is arranged in a capsule, which is preferably hemispherical or hemicylindrical. The planar surface, the longitudinal planar surface if the capsule is hemicylindrical, faces upwards and is covered by a membrane that will transfer pressure easily. The remaining walls of the capsule are preferably insulated so that no pressure or pressure changes will be transferred through these walls. In this way, only pressure and pressure changes taking place above the capsule will be registered. The sensor should be sensitive to low frequency pressure changes, in the range from 0Hz to 10Hz.

Figure 2 shows a cross-section of a mattress 25 according to a preferred embodiment of the invention, seen from the side, with a person lying on it. The difference compared to Figure 1 is that the control device 29 is built into the head end of the mattress. The control device may of course be placed in other parts of the mattress, but the head end is feasible, since the control device can easily be placed there without being noticeable to the person lying on the bed. The number of cables needed is also reduced.

The mattress 25 has an upper 26 and a lower 27 layer. The upper layer is made of, for example, foam rubber with air channels, approximately 7-8 mm wide, running across the mattress with approximately 5cm between the channels. As shown in the figure, the air channels widen at the bottom. Thus 15-20% of the surface on which the person is lying is air. the rest is foam rubber or another suitable material which adapts better to the shape of the body because of the air channels.

One or more weight sensors 31 are arranged in the mattress in the region on which the person's hips will be located, for registering presence and movements. Sensors for heart and lung activity, 33 and 35 respectively, are arranged in the mattress below the chest of the person.

One or more loudspeakers 41 and microphones 43 are arranged in the head end of the mattress. The microphones 43 may be used for registering breathing or snoring, and the loudspeakers may be used for generating calming sound pulses. Microphones and loudspeakers may also be used for phase cancellation purposes in a system to reduce disturbing noise from outside traffic or other sources such as air conditioning systems.

Figure 3 shows examples of connections between the control device and other electronic components that may be used in connection with the system. A control apparatus 51, essentially a computer comprising the appropriate software, receives signals from the microphones, pressure sensors and heart and lung activity sensors found in the mattress. The signals are processed in the control apparatus 51 and used to control a sound system 53 and a driver 55 for the vibration elements.

The sound system 53 is connected to the loudspeakers of the mattress and possibly with one or more other sound sources 57, such as a television set, a stereo or a computer. In the latter case the sound system 53 may function as an amplifier. The sound system 53 may also receive signals from one or more microphones 59 that register disturbing noise, and, based on a signal from these microphones generate an phase cancelling noise that is sent to the loudspeakers in the mattress and/or to loudspeakers arranged outside the mattress, thus reducing the noise.

The mattress may also comprise other types of sensors, for example, for blood pressure, muscle tension, temperature and galvanic skin response. In this case the control apparatus 51 or a separate apparatus 69 connected to the control apparatus must comprise functions for handling information from these sensors.

A remote control 71 may be used for controlling the functions of the mattress. For example, infrared waves or radio frequency waves may be used for the communication between the remote control 71 and the control device 51. The remote control

may also have a display showing relevant data, for example, the time, the alarm functions that are active, or the heart rate, or whether or not the sleep was interrupted during the night.

5      Figure 4 shows the data processing and communications system according to a first preferred embodiment of the invention. According to this embodiment, the analogue signals from the sensors in the mattress are converted, in an analogue to digital (A/D) converter 101 to digital signals which are then fed to a Digital Signal Processing (DSP) computer 103. The DSP computer may also perform the functions described in connection with the control apparatus 51 in Figure 3.

10     The DSP computer 103 comprises signal processing algorithms needed to perform supervising functions, such as

- Detecting the presence of someone lying on the mattress,
- Detecting when the heart and breathing rate can be evaluated,
- Evaluating the heart and breathing rate when possible,
- Detecting and reporting asthma attacks,
- Detecting and reporting epileptic seizures,
- Detecting the risk of developing pressure sores by monitoring position changes,
- Detecting weight changes, which may be associated with, for example, water retention.

15     The processed data may lead to information being transmitted through a communications module 105 to a supervision unit 109. The communications module 105. In a preferred embodiment, the communications module 105 is adapted to wireless communication, for example, in a cellular system known in the art. For example, if the processed data indicates that the person has left the bed, information to this effect, including the time when this was registered, may be transmitted. If the processed data indicates that the heart function is irregular, an alarm signal stating the nature of the problems may be transmitted.

This information may be transmitted, in any way known in the art, for example, through a router 107 to a stationary supervising unit 109 or a mobile telephone carried by a nurse. If transmitted to a mobile telephone, the Short Message System (SMS) may be used, or a voice message may be sent. The DSP computer 103 or the communications module 105 must then comprise a unit for inserting voice messages or SMS, respectively. The communications module 105 also comprises encrypting means for encrypting the data being transmitted.

5            Of course, the digital data, or even analogue data, may be fed to a communications module without any processing. The data may be transmitted from the communications module directly to a supervising unit, in which it may be processed, and displayed if desired.

10          In another embodiment the data may be transmitted from the computer or control device directly to the supervising unit via a modem, in the way common in the art.

15          The GSM standard currently comprises two standards for high-speed data transmission: Global Packet Radio Services (GPRS) and High Speed Circuit Switched Data (HSCSD), both of which may be used. An Integrated Services Digital Network (ISDN) may also be used for transmitting data.

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25          Figure 5 shows, schematically, the data processing and communications system according to a second preferred embodiment of the invention, for use in an old people's home, a hospital or the like. This implementation is based on an in-house cellular system, such as a DECT system. In Figure 5 one floor of the house is shown, comprising a number of bedrooms 201. Each bed 203 comprises a number of sensors, as discussed in connection with Figure 1, and a wireless communications module 205, which in this case is a DECT transmission unit. A processing unit (not

shown) such as the DSP computer may be used for processing the data before transmission.

In the middle of the floor, for example in connection with cloakrooms or a storage room, a receiving antenna 207 is placed, to receive signals transmitted from the communications modules 205 in the bedrooms 201. The data may be transmitted directly to a supervision unit 209, or some basic processing may be carried out before transmission. It would of course be possible to process the data in units placed in the bedrooms before transmitting it. The nature of the transmitted data depends on whether or not any processing is done before transmission. The transmission is carried out according to the standard local area wireless protocol applicable, for example IEEE 802.11.

Of course, the number of antennas, and their position, may vary depending on the size of the house, and the number of incoming signals to be processed. The receiving antenna is connected to a supervising unit, preferably located in a separate room on the same floor. One supervising unit can of course receive data from several antennas, on different floors if desired. Data from more than one room may be transmitted to the same local unit for processing before being transmitted to the supervision unit.

The control device may, in addition to processing data and forwarding information through the communications system, control the functions of the mattress in dependence of input signals from a remote control or according to information from the microphones 43 and the sensors 31 33, 35 in the mattress as described above. It may also be programmed to respond to deviations from the normal, for example, triggering an alarm if a stable heart rate becomes unstable or if the respiration stops.

Instead of wireless transmission, of course any other transmission system could be used. In this case, the communications modules 205 would have to be adapted to

this other transmission system, and each module would have to be connected to the supervision unit 209. The wireless system, however, has a number of advantages. It is easy to install and units may easily be moved or changed as needs change.

5      Figure 6A shows a vibration element 1 according to a preferred embodiment of the invention. The vibration element comprises a vibrating body 3 positioned in a plane form 5, preferably forming a lattice. This plane form 5 distributes the vibrations to an area around the vibrating body. It is feasible to arrange the vibrating body 3 in the middle of the plane form 5, but it may also be placed in other positions. Different kinds of vibrating bodies 3 may be used, but with the limitation that the electromagnetic field generated must not become too strong.

10

In a preferred embodiment the vibration element 1 is located in a mattress or an air cushion and generates vibrations by an air pressure, hydraulically, by a method known in the art, converts air or liquid pressure to vibrations in a piston, or a spherical body, to controlled pulse vibrations with a controlled frequency and amplitude. To protect the user from electromagnetic fields, only small electromagnetic valves are used to generate the desired pulse vibrations in each vibrating body. These valves are EMC protected by a suitable material. They are also placed deep in the mattress, at the maximum distance from the person lying on the mattress.

15

20

In another embodiment solenoids are used. The solenoids are controlled by a low voltage (preferably 2V-6V) so that a weight is moved back and forth to generate vibrations. This is possible with solenoids in which the electric flux is directed inwards in the solenoid so that only a small electromagnetic field is generated around the solenoids. In order to further reduce the electromagnetic field in the heart region of the person, the solenoids may be arranged at the foot of the bed. It may also be appropriate to shield the solenoids in some way.

25

In order to follow the shape and movements of the body the plane form 5 should be flexible in all directions and made from a material that is sufficiently rigid, but not too rigid to be pliable. The design and the material should also be selected so that the plane form 5 resumes its original shape after being bent. What is the best suited  
5 material depends on the material selected for the mattress. In a preferred embodiment the plane form 5 is designed as a square lattice in pliant nylon, approximately 25cm x 25cm and comprises two rows of five ribs in a material of a proper rigidity, at a uniform mutual distance, perpendicular to each other. Each rib has a profile similar to the one shown in Figure 6B. The plane form may also have other shapes,  
10 for example, a number of concentric circles in the sufficiently rigid material, with the vibrating element 3 in the centre and a number of ribs in the material arranged as the "spokes" in a wheel.

The vibration element 1 may be controlled manually, by means of a control device,  
15 for example a remote control, or automatically by a processor controlling the vibrating body 3 in dependence of time or on the basis of registered data about the person's heart rate or the like, as described above. Of course, a combination of manual and automatic control may be used.

20 One or more vibration elements 1 may be arranged in armchairs, seat cushions or pads that may be placed under cushions, or, as shown in Figure 1, a number of vibration elements may be arranged in a mattress.

## Claims

1. A communications system for transmitting information about the state of a person, characterized in that it comprises

5 - a mattress comprising at least one type of sensor (13, 15, 17, 19; 31, 33, 35, 43) for registering at least one body function of a person lying on the mattress,  
- a communications module (105) for transmitting data through a standard telecommunications interface.

10 2. A communications system according to claim 1, characterized in that the communications module (105) is adapted for wireless communication.

15 3. A communications system according to claim 1 or 2, characterized in that it comprises a signal processing means (103) and means (101) for converting the output signals from the sensors to input signals of the appropriate format for the processing means (103).

20 4. A communications system according to any one of the preceding claims, characterized in that the mattress comprises pressure sensors (13; 31) in the hip region.

5. A communications system according to any one of the preceding claims, characterized in that the mattress comprises acoustic sensors (15, 17; 33, 35) in the chest region.

25 6. A communications system according to any one of the preceding claims, characterized in that the mattress comprises pressure sensors (19) in the chest region.

30 7. A communications system according to any one of the preceding claims, characterized in that the sensors (13, 15, 17, 19; 31, 33, 35) are essentially the same type of acoustic pressure sensors, each transmitting a signal comprising a spectrum of

frequencies and that the processing means (105) comprises functions for separating the signal frequency components.

8. A communications system according to any one of the preceding claims, characterized in that the mattress comprises air compartments surrounded by a flexible material.

9 A communications system according to claim 8, characterized in that the sensors are located in the air compartments, each sensor being enclosed in an essentially hemispherical or hemicylindrical capsule.

10. A method registering and communicating information, characterized by  
- registering data about the body functions of a person lying on a mattress by means of sensors located in the mattress  
15 - transmitting the data through a standard telecommunications interface.

11. A method according to claim 10, characterized by  
transmitting the data through a cellular telecommunications interface.

20 12. A method according to claim 10 or 11, characterized by the step of converting the data to a format readable by a computer and processing the data in a computer before transmitting it.

25 13. A method according to any one of the claims 10-12, characterized by the steps of registering the presence or absence of a person on the mattress by means of sensors, automatically starting the registration of other data when the presence of a person on the mattress is registered, and automatically ending the registration of other data when no person is found to be on the mattress.

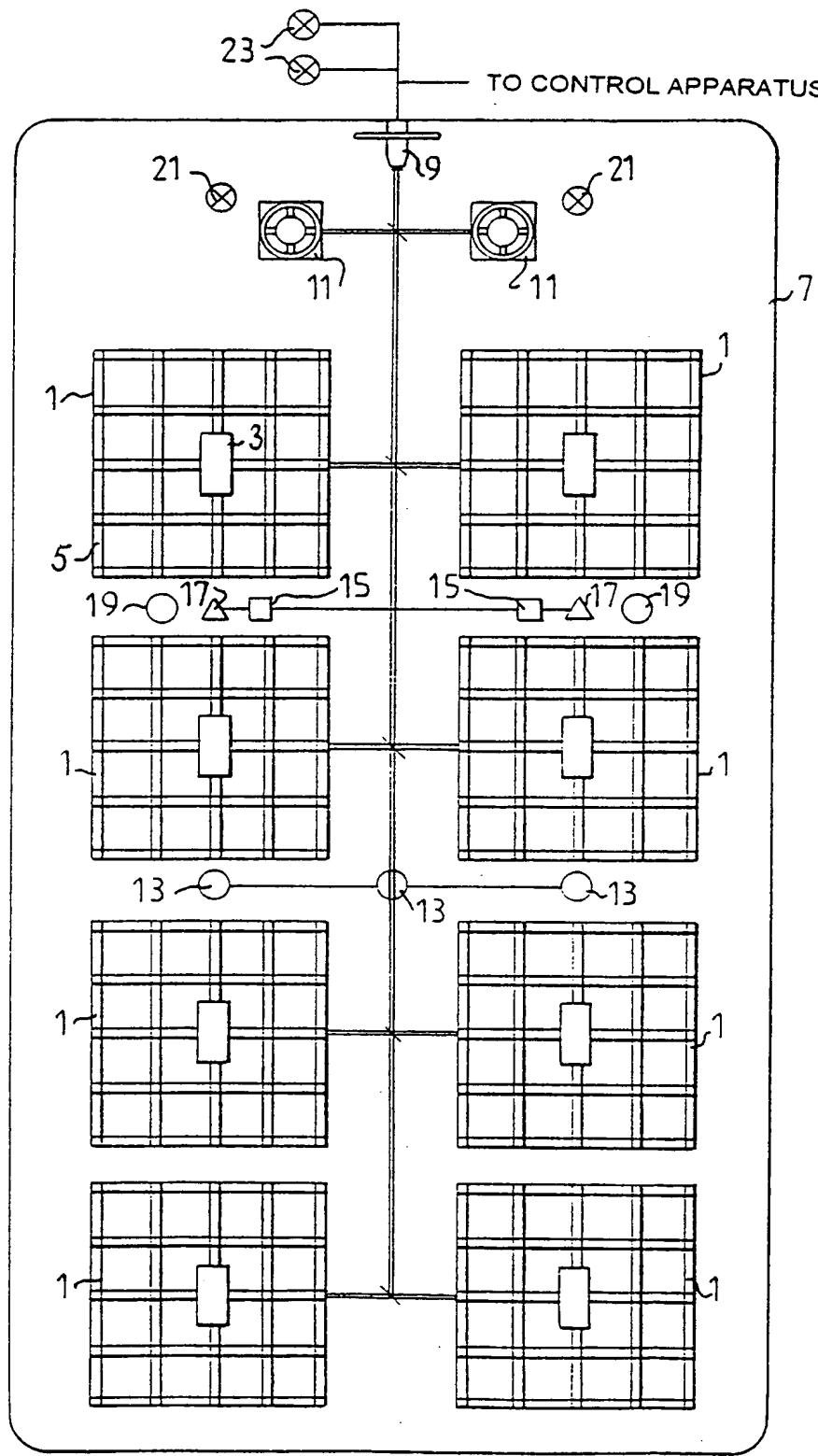


Fig. 1

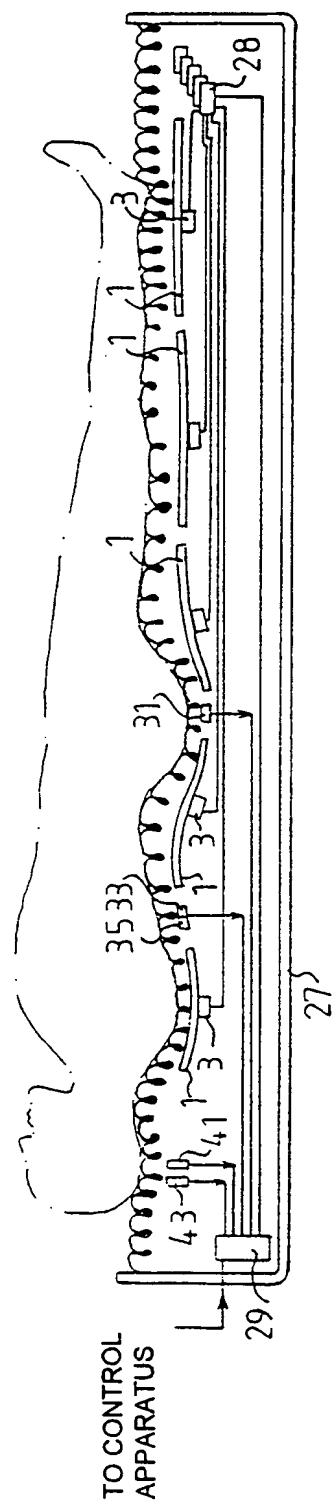


Fig. 2

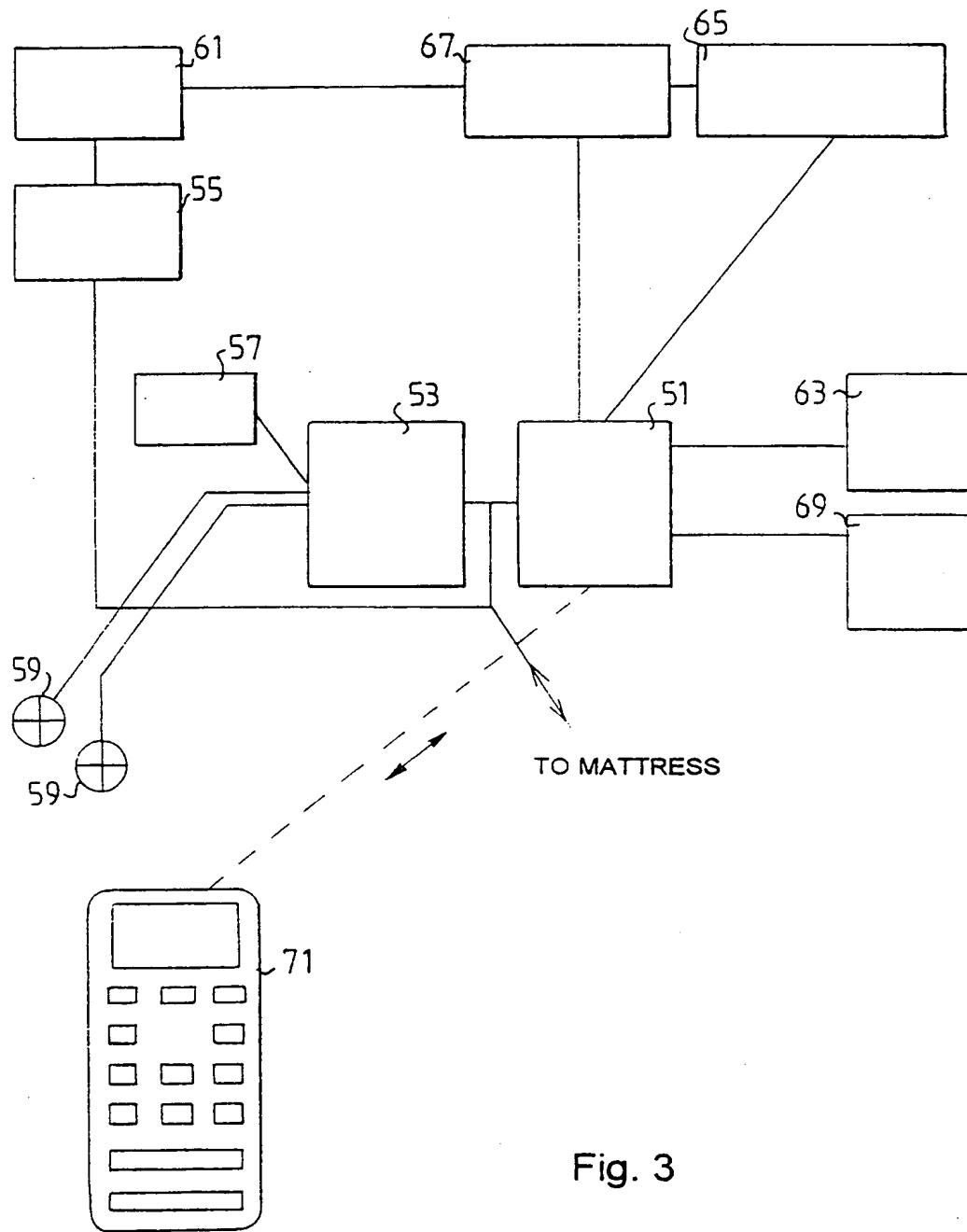


Fig. 3

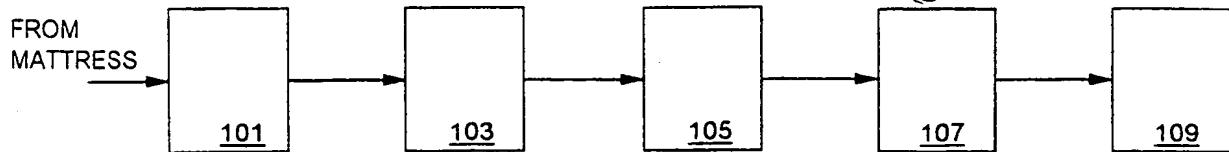


Fig. 4

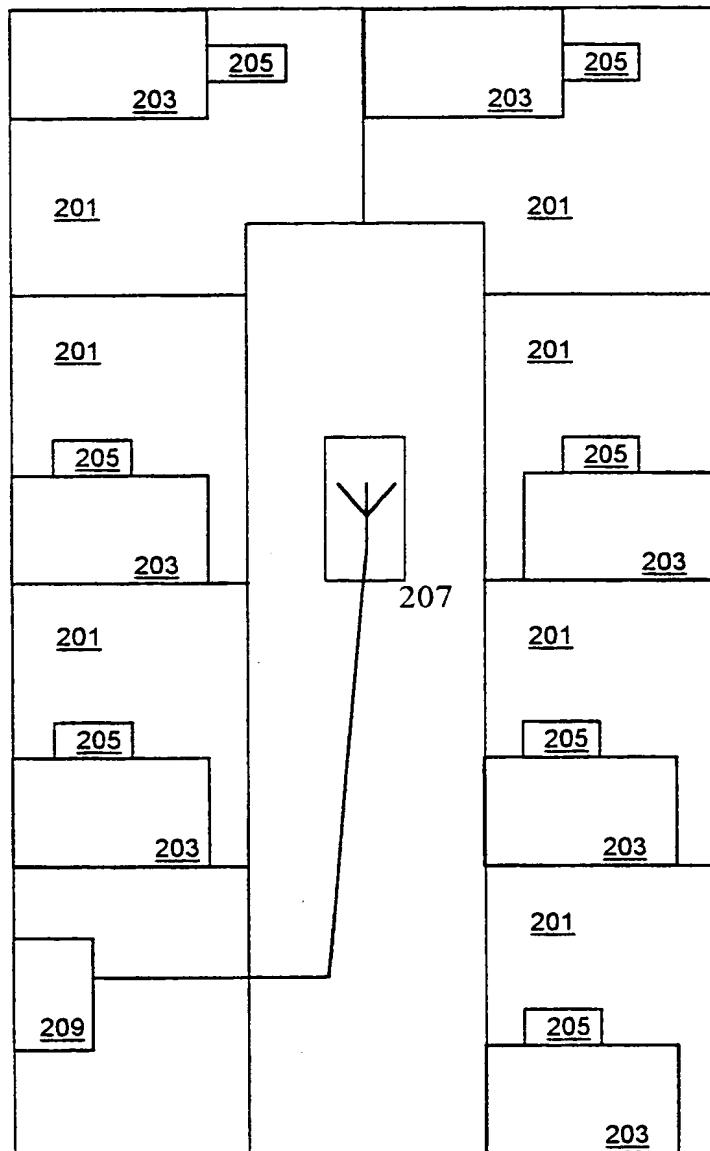


Fig. 5

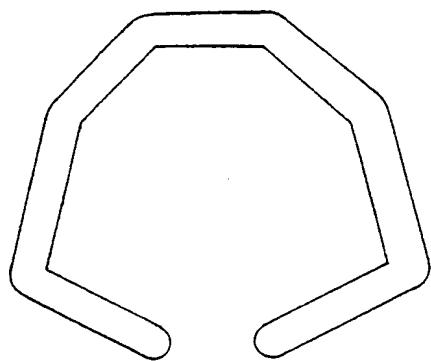


Fig. 6B

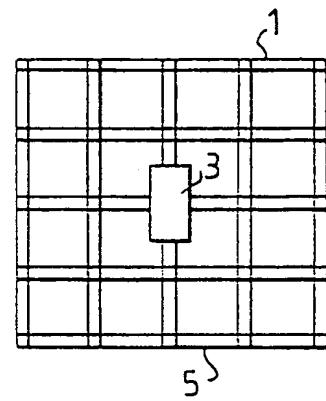


Fig. 6A

## INTERNATIONAL SEARCH REPORT

International application No.

PCT/SE 98/00211

## A. CLASSIFICATION OF SUBJECT MATTER

**IPC6: A61G 7/05, H04M 11/00 // A 61 B 5/0205, A 61 B 5/11**  
 According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

**IPC6: A61B, A61G, H04M**

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

**SE,DK,FI,NO classes as above**

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

**WPI**

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 8605965 A1 (EMERGENT TECHNOLOGY CORPORATION), 23 October 1986 (23.10.86), page 7, line 26 - page 8, line 3; page 11, line 9 - line 20; page 27, line 13 - line 22	1,3,4,6,10, 12,13
Y	--	2,5,7-9,11
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 Further documents are listed in the continuation of Box C. See patent family annex.

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## INTERNATIONAL SEARCH REPORT

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PCT/SE 98/00211

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Information on patent family members

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